AMBIENT AIR QUALITY IN THE SARNIA AREA

Annual Report 1978

Ministry of the Environment
Ontario

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SUMMARY

Ambient air quality determined for 1978 through the monitoring networks of the Ontario Ministry of the Environment displayed a mixture of results. Levels of sulphur dioxide remained unsatisfactory in downtown Sarnia with the criteria for desirable ambient air quality established for 1-and 24-hour periods being exceeded more frequently than during the previous few years. Occasionally the criterion for 1 hour was exceeded at monitoring sites immediately south of Courtright while the 24-hour criterion was not exceeded. Neither the 1-nor 24-hour criteria were exceeded at the monitoring site in east Sarnia. The criterion established for the annual average concentration of sulphur dioxide was not exceeded at any site. A control strategy is being developed to prevent excursions of the 24-hour criterion in downtown Sarnia as well as to reduce the frequency of excursions above the 1-hour criterion.

Elevated levels of particulates were measured in downtown Sarnia and are attributable in part to emissions from major construction. At other monitoring sites, particulate levels were generally satisfactory.

In downtown Sarnia and at a rural site east of Sarnia levels of ozone were detected above the criterion for desirable ambient air quality. Excursions above the criterion are experienced throughout much of North America. The excursions are primarily attributed to the combination of long-range transport of ozone into areas like Sarnia and the formation of ozone by photochemical reactions involving pollutants transported into these areas as well as pollutants emitted by local sources. Control of ozone will be dependent on the development of compatible control strategies for local emissions and pollutants brought into the area by long-range transport of air masses.

Levels of carbon monoxide and nitrogen dioxide measured in Sarnia met the respective criteria for desirable ambient air quality. There were occasional excursions in downtown Sarnia above the criterion established for hydrogen sulphide, an offensively odorous gas.

Levels of fluorides, measured by fluoridation rate, were detected above the criteria for desirable ambient air quality in downtown Sarnia and south of Courtright in the vicinity of power generating plants and the fertilizer complex of Canadian Industries Limited. The criteria are based on the protection of vegetation. However, phyto-toxicology surveys, which are more discriminating than air monitoring, revealed no vegetation damage attributable to fluorides in Sarnia or outside of company property in the area south of Courtright.

INTRODUCTION

South of Sarnia there is a high density of industries and power plants on both sides of the St. Clair River. Emissions from the industries and power plants located in Ontario are regulated through a Certificate of Approval. To determine the effectiveness of the Certificate of Approval and related pollution control measures, ambient air quality monitors are operated by the Ministry of the Environment as well as by Ontario Hydro, the Lambton Industrial Society and private industry. In addition, to the monitoring of ambient air quality the Ministry conducts phytotoxicology surveys to determine the effects of air pollutants on vegetation. The Ministry also carries out mathematical modelling of the dispersion of pollutants to evaluate levels of pollutants in areas where monitors are not located and to determine the best locations to site monitors.

This report presents the 1978 data for ambient air quality obtained through the monitoring network of the Ministry of the Environment and compares 1978 data to that of previous years.

DESCRIPTION OF MONITORING NETWORK

Continuous and intermittent monitors for determining the levels of pollutants in ambient air are maintained by the Ministry at sites dispersed throughout the Sarnia area. Monitoring is most intensive in the area of downtown Sarnia because it is affected by emissions from industries and power plants to the south, as well as from dense vehicular traffic and commercial establishments in the downtown area. It is therefore believed that the downtown area is likely to experience higher levels of pollution than most other sections

of the City. The locations of the sites are illustrated in Figure 1, Appendix 1 and specific locations and pollutants monitored are listed in Table 1, Appendix 1.

In July, 1978 a new main monitoring station was established at Centennial Park (station number 14064). The new station replaced the previous main monitoring station on Victoria Street (station number 14049) that will be affected by the redevelopment of downtown Sarnia. Station 14064 is located close to the downtown area of Sarnia but its relative remoteness to parking lots and heavy traffic makes it a more representative station than station 14049. Station 14064 also replaced station 14049 in providing data for the Air Pollution Index.

In the last half of 1978 two monitoring stations (numbers 14030 and 14031) were established to provide information on the level of suspended particulates in the vicinity of Tricil Limited, Moore Township.

Criteria for desirable ambient air quality and the principal rationale for the establishment of these criteria appear in Table 2, Appendix 1.

METEOROLOGICAL DATA

Meteorological data are utilized in predicting the stability of the atmosphere which affects the dispersion of pollutants. These data are also used to assist in identifying sources of elevated levels of pollutants and to validate mathematical models designed to simulate the dispersion of air pollutants.

At 10 metres, 30metres and 92 metres above ground level, wind speed and direction are measured at station 14016 immediately south of Courtright. In addition, ambient

air temperature is measured at the 10-metre level and the gradients in temperature between the 10-metre level and the 30-and 92-metre levels are determined. These meteorological data are telemetered to Toronto where meteorologists utilize them to forecast the stability of the atmosphere. This forecasting feature is an intrinsic part of the Air Pollution Index.

Wind speed and direction are also measured at the 10-metre level at station 14062, located in east Sarnia.

Meteorological data from the 30-metre level of station 14016 have been used to compute the average concentrations of sulphur dioxide for specific wind directions, in order to correlate elevated levels of suspended particulates with wind direction, and to determine the number of hours the criterion for ozone has been exceeded for different wind directions.

A summary of the frequency of winds for different directions at the 30-metre level of station 14016 appears in Table 3, Appendix 2.

PARTICULATES

Primary sources of man-caused emissions of particulates to the atmosphere are vehicular traffic, materials handling and combustion processes. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as suspended particulates, dustfall and soiling index. Suspended particulates are determined by drawing measured volumes of air through a pre-weighed filter for 24 hours and subsequently weighing the quantity of particulates collected on the

filter. Dustfall is determined through the exposure of open cylinders (jars) of known diameter for approximately 30 days and subsequently weighing the amount of particulates collected. Soiling index is measured by determining the difference in the amount of light that is transmitted through a filter before and after ambient air is drawn through the filter for 1 hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Since soiling index can be correlated to levels of suspended particulates and can be determined immediately without the time-consuming laboratory analysis required for the determination of concentrations of suspended particulates, soiling index is used as a substitute for suspended particulate values when data are required quickly.

SUSPENDED PARTICULATES

Criteria for desirable ambient air quality with respect to suspended particulates are 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period, and 60 ug/m^3 as the annual geometric mean for 24-hour samples. The 24-hour criterion is based on impairment of visibility and adverse effects to health associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on damage to property.

Total suspended particulates were sampled at 13 sites in the Sarnia area on a schedule of every sixth day. Sampling at 3 of the 13 sites was restricted to a period near the end of the year and consequently data are not representative of the whole year. For the remaining 10 sites the annual criterion was exceeded only at stations 14049 and 14051, located in the downtown core of Sarnia where construction and vehicular traffic would be a significant

contribution to levels of particulate. The 24-hour criterion was exceeded at the 10 representative sites with the greatest frequencies of excursions occurring at stations 14049 and 14051. The remaining eight stations had either 1 or 2 values above the 24-hour criterion. Considering that each year there are usually several days with conditions (of adverse dispersion) such that the 24-hour criterion is exceeded even in areas remote from major sources of particulates, air quality in the Sarnia area was satisfactory with respect to suspended particulates, except for the downtown core.

On May 26, 1978, levels of suspended particulates were above the 24-hour criterion at all operating stations and the maximum level for the year was reported for 9 of the 10 stations. Winds were generally southerly and south-westerly with low wind speeds. Temperature inversions that could adversely affect dispersion were experienced both early and late in the day. Photochemical oxidants were elevated during much of the day, which would result in the formation of aerosols that would be measured as suspended particulates. A review of meteorology and pollution levels indicate that elevated levels of particulates on days such as May 26, 1978 would be attributable to a combination of local emissions and pollutants transported into the Sarnia area.

Data for the 3 monitoring sites that operated for only the latter part of 1978 were not above the criteria. Two of these sites (stations 14030 and 14031) were located in the rural area next to Tricil Limited, in Moore Township, while the other site was at station 14064, located immediately north of the downtown core of Sarnia.

Table 4, Appendix 3 contains a summary of 1978 data for total suspended particulates while Figure 2 illustrates data summarized for 1978 for different monitoring locations.

Figure 3, Appendix 3 contains a summary of data for suspended particulates for 1972 to 1978. From this Figure it is evident that levels of suspended particulates in recent years are substantially lower than in 1972.

Correlations between levels of suspended particulates determined for samples collected from the 10 sites that operated throughout 1978 and data for wind speed and direction from the 46-metre level of station 14016, south of Courtright, were determined. The correlations are shown in Figure 4, Appendix 3, with the length of line corresponding to the various wind directions indicating the strength of the positive correlations. The positive correlations occur with winds from the south-south-east, south, south-south-west and south-west. This may be attributable to many point sources of particulates being south to south-west of Sarnia and aerosol formation from photochemical oxidation being greatest with southerly to south-westerly winds.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 7 stations in Windsor were analysed for cadmium, chromium, copper, iron, lead, manganese, nickel, nitrate, sulphate and vanadium. A summary of the data for 1976 through 1978 is contained in Table 5, Appendix 3.

Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium. Concentrations of the various metals have been low with no values above the criteria. There is no apparent trend of increasing levels of metals in suspended particulate matter. Average levels of nitrates and sulphates were slightly higher during 1978 than 1976 or 1977.

DUSTFALL

The Ministry of the Environment's criteria for desirable ambient air quality with respect to dustfall are 7.0 grams of particulates per square metre per 30 days (gms/m^2/30 days) in any single month and an annual average of 4.6 gms/m^2/30 days. These criteria are based on historical data and criteria established by other enforcement agencies.

Dustfall is sampled at stations 14049 and 14051, located in the downtown core of Sarnia. Data for recent years have indicated acceptable levels of dustfall in the downtown core. However, levels for 1978 were appreciably higher at station 14051 and the levels for March and April at station 14049 were elevated, also. The increase in dustfall is (at least in part) attributable to emissions resulting from major construction in the downtown core. Table 6, Appendix 3 contains the data for 1972 to 1978.

SULPHUR OXIDES

Combustion of sulphur-containing fuels such as coal and oil is the largest man-made source of sulphur dioxide emissions to the atmosphere. In the Sarnia area large quantities of these fuels are consumed by power-generating plants in Michigan and Ontario and by petroleum and petrochemical industries located south of downtown Sarnia.

Sulphur oxides are monitored in the Sarnia area by this Ministry as gaseous sulphur dioxide using continuous monitors, as sulphate in suspended particulates by laboratory analysis and as sulphation rate. Sulphation rate is determined through the exposure of a filter coated with lead peroxide

for a period of approximately 30-days and afterwards quantitatively analyzing the filter for sulphate. The sulphate is formed by the oxidation of sulphur compounds to lead sulphate.

SULPHUR DIOXIDE

During 1978 the Ministry of the Environment monitored gaseous sulphur dioxide continuously at 5 separate locations in the Sarnia area. There were 14 additional sites where monitors providing continuous measurements of sulphur dioxide were operated by Ontario Hydro, the Lambton Industrial Society or private industry.

Data are reported as 1-hour average concentrations, 24-hour average concentrations and annual average concentrations. Criteria for desirable ambient air quality are 0.25 parts of sulphur dioxide per million parts of air (ppm) during a 1-hour period, 0.10 ppm averaged for 24 hours and 0.02 ppm as an annual average. The criteria for the 1-hour and annual averages are based on the protection of vegetation while the 24-hour criterion is for the protection of human health.

During 1978, the annual criterion was not exceeded and the 24-hour criterion was exceeded only at station 14049 in downtown Sarnia; however, the 1-hour criterion was exceeded at 4 of the 5 stations operated by the Ministry. In general, there were more frequent excursions of the 1-hour and 24-hour criteria during 1978 than in 1977, with the most frequent excursions occurring in downtown Sarnia. At station 14062 in east Sarnia none of the criteria were exceeded.

Stations 14004 and 14016 are located south of Courtright in the environs of the Lambton Generating Station of Ontario Hydro and the St. Clair Generating Station of Detroit Edison. All excursions above the 1-hour criterion

at these monitoring stations occurred during afternoons and persisted for several hours, although not long or severe enough to create excursions above the 24-hour criterion. A summary of 1978 data for sulphur dioxide appears in Table 7, Appendix 4, while Figure 5 illustrates the trend in decreasing frequencies of excursions above the 1-hour and 24-hour criteria for those stations operating at least 2 years.

Pollution roses for sulphur dioxide are presented in Figure 6, Appendix 4 and were created using data for wind direction and speed from the 30-metre level of station 14016 and concentrations for sulphur dioxide determined at the various stations in the area. The longer the line corresponding to specific wind directions, the stronger the correlation. The roses for station 14049, 14062 and 14064 illustrate that sources south of downtown Sarnia elevated average concentrations of sulphur dioxide. The rose for station 14016 reveals the influence of sources north of the monitoring site as well as a slight effect from the south and south-south-west, where the St. Clair Generating Station is located. The rose for station 14004 indicates a slight influence from sources north of the monitoring site but no appreciable influence from the St. Clair Generating Station. The lower average values reported for station 14004 are in part due to the instrument being operated in a less sensitive range, resulting in a greater tendancy to record low concentrations as zero.

The Ontario Ministry of the Environment is in the final stages of developing a control strategy for sulphur dioxide that would have major emitters in Lambton County provide additional controls or cut back emissions when winds are forecast to persist from a southerly direction and elevated levels of sulphur dioxide are recorded. The elevated levels of sulphur dioxide that will trigger the additional controls will be below the 24-hour criterion to allow for a suitable period of time during which the controls may be brought into operation.

SULPHATION RATE

The criterion for desirable ambient air quality for sulphation rate is 0.7 milligrams of sulphur trioxide per 100 square centimetres of exposed lead peroxide per day (mg SO_3/100 cm^2/day) after an exposure period of approximately 30 days. This criterion was developed for the protection of vegetation from correlations between sulphation rates and levels of sulphur dioxide that would protect vegetation. Recent studies by the Ministry of the Environment have shown large differences in correlations from site to site such that the criterion for sulphation rate does not necessarily reflect levels of sulphur dioxide that protect vegetation. Consequently, it is the Ministry's intention to replace the criterion established for sulphation rate with a guideline which, if exceeded, would result in consideration being given to installing a monitor for gaseous sulphur dioxide. In Lambton County the network of sulphur dioxide monitors has been gradually expanded so that it is now sufficient to define air quality without measurements of sulphation rate. Hence, measurement for sulphation rate was terminated early in 1979.

Data for 1978 are presented in Table 8, Appendix 4. As the data for gaseous sulphur dioxide indicate, the measurements for sulphation rate show higher levels at stations 14049 and 14051 in the downtown area of Sarnia.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forcasting and current readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of high pollution conditions that are reported as the API.

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are inserted into the following equation:

$$\text{1-hour API} = 0.18\ (31.15\ \text{COH} + 124.6\ SO_2)^{1.37}$$

where: COH is soiling index expressed in units of coefficient of haze

SO_2 is sulphur dioxide expressed in parts per million.

The 1-hour API is used to compute a running average for 24 hours which is reported as the official API.

API values below 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, those responsible for major emissions are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. When the API reaches 100 all industries and other contributors of pollution not essential to public health and safety may be ordered to cease operations.

Although the API is based on the control of combined levels of sulphur dioxide and suspended particulates, emissions of other pollutants would be controlled simultaneously.

However, situations may occur where levels of certain pollutants such as ozone may be high and the API may be quite low. The normal monitoring program of the Ministry is used to detect these elevated levels of other pollutants.

During the first half of 1978 the API was determined from monitors located at station 14049 in downtown Sarnia. Because of redevelopment in downtown Sarnia, the monitors were moved in July to station 14064 in Centennial Park, north of downtown Sarnia. In January, 1978 the Advisory Level was reached for 28 consecutive hours with the maximum value being 41. In November the API reached the Advisory Level for 24 hours at station 14064 with the maximum API value being 35. Both the January and November periods of elevated API values occurred when there were adverse dispersion conditions over much of southern Ontario and elevated API values were also experienced in other cities. With the exception of the January and November periods the API for Sarnia was in the acceptable range.

HYDROGEN SULPHIDE AND MERCAPTANS

Mercaptans are a group of organic compounds that contain sulphur and hydrogen and exhibit characteristics similar to hydrogen sulphide. Hydrogen sulphide is commonly referred to as rotten egg gas and many mercaptans are also malodorous at extremely low concentrations.

Both hydrogen sulphide and mercaptans originate in nature from anaerobic decomposition of organic matter containing sulphur. In the Sarnia area, the release of hydrogen sulphide and mercaptans into the atmosphere may result from the processing of petroleum feedstocks containing sulphur.

The criterion established to represent desirable ambient air quality with respect to hydrogen sulphide is 0.02 ppm as an average for 1 hour. This criterion is based on the offensive odours exhibited by this gas. Similarly, the criterion for mercaptans is based on odour and was established as 0.01 ppm averaged for 1 hour and expressed as methyl mercaptan.

Unfortunately, the monitoring instrument in Sarnia does not segregate hydrogen sulphide from mercaptans but determines the total combined concentrations of hydrogen sulphide and mercaptans and expresses these concentrations in terms of hydrogen sulphide. To adjust for this situation the combined concentrations of hydrogen sulphide and mercaptans are compared to the less restrictive criterion for hydrogen sulphide.

The monitor in downtown Sarnia was relocated after the first 8½ months of 1978 from station 14049 where it had been operated since 1974 to station 14062 in east Sarnia. During 1978 the hourly criterion of 0.02 ppm was exceeded 9 times at station 14049 and on no occasion at station 14062. A summary of data presented in Table 9, Appendix 5 shows that the frequency of excursions was slightly higher in 1978 than frequencies reported for 1977 and 1976 but well below frequencies experienced during 1974 and 1975. Annual average concentrations for combined hydrogen sulphide and mercaptans have been constant since 1975.

CARBON MONOXIDE

Combustion processes represent man's major emissions of carbon monoxide. Emissions from motor vehicles are most significant because they occur near ground level and are concentrated in urban areas where the public may be exposed for long periods. Industries and power-generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in the ambient air.

The criteria for carbon monoxide, which are based on the protection of human health, are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8-hour period.

Carbon monoxide was monitored at station 14049 in downtown Sarnia for the first half of 1978 and then at station 14064 in Centennial Park during the latter part of the year. The criteria for desirable ambient air quality were not exceeded at either station. As expected, owing to a lower volume of vehicular traffic, levels recorded at station 14064 were lower than levels determined at station 14049.

A summary of data for carbon monoxide obtained since 1972 is presented in Table 9, Appendix 5, which illustrates long-term conformity below established criteria.

OXIDES OF NITROGEN

Oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are the compounds of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria, which are based on the protection of human health and offensive odours, are 0.20 ppm, averaged for 1 hour and 0.10 ppm averaged for 24 hours. During the first half of 1978 the monitor for oxides of nitrogen (which reports values for nitric oxide, nitrogen dioxide, and total oxides of nitrogen) was sited at station 14049 in downtown Sarnia, while during the latter part of the year it was located at station 14064. The criteria established for nitrogen dioxide were met at both sites, although average values of nitrogen dioxide were slightly lower at station 14064 where less motor vehicular traffic is experienced.

A summary of data for oxides of nitrogen, presented in Table 9, Appendix 5, illustrates that levels of nitrogen dioxide are consistently below the established criteria. The levels of nitric oxide and total oxides of nitrogen are in a range typical for communities the size of Sarnia.

Oxides of nitrogen in combination with reactive hydrocarbons under certain meteorological conditions play an important role in the formation of unsatisfactory levels of photochemical oxidants. Therefore, consideration is being given to further controlling the levels of oxides of nitrogen.

HYDROCARBONS

Emissions from motor vehicles are a primary man-made source of hydrocarbons in the ambient air. Other significant man-made sources are incomplete combustion of fuels by industries and power plants, and evaporation losses during the storage and transportation of hydrocarbons. Natural phenomena also produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Total hydrocarbons were measured in downtown Sarnia at station 14049 for the first half of 1978 and at station 14064, north of downtown Sarnia, during the latter half of 1978. Average levels measured at station 14064 were less than levels at 14049 due to the lower volume of motor vehicle traffic. The summary of data for total hydrocarbons that appears in Table 9, Appendix 5 shows no significant trend in the levels of total hydrocarbons from 1972 to 1978.

OXIDANTS

Oxidants in the ambient air are primarily a result of a series of photochemical reactions and inter-reactions involving oxides of nitrogen and hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine, resulting in higher levels of oxidants in the spring and summer months.

The Ministry of the Environment measured oxidants in the form of ozone at station 14049 in downtown Sarnia for the first half of 1978, at station 14064 north of downtown Sarnia for the remainder of 1978, and throughout 1978 at station 14118 situated in a rural setting approximately 10 kilometres east of Sarnia. Ozone normally accounts for 80 to 95 percent of the oxidants present in ambient air. Consequently, with technology for monitoring ozone being more accurate and efficient than for total oxidants, most regulatory agencies monitor for ozone.

Long range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) may account for a very significant portion of local levels of ozone. Long-range transport from distances greater than 200 kilometres have been reported in the literature. Therefore, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

Ozone is also present in the stratosphere where it plays a critical role in absorbing excessive amounts of ultraviolet solar radiation that may be biologically harmful. Occasionally ozone from the stratosphere may be transported downwards to create elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

The criterion for desirable ambient air quality established for ozone is 80 parts per billion (ppb) averaged for 1 hour. This criterion was established for the protection of vegetation and human health. Some effects that are detrimental to health and are associated with oxidants are eye irritation and a decrease in the performance of atheletes.

During 1978 the criterion was exceeded 249 times at station 14118, the rural site east of Sarnia, while 107 excursions were recorded at the two Sarnia sites (51 at station 14049 and 56 at station 14064). Average concentrations for stations 14049, 14064 and 14118 were 23, 18 and 29 ppb, respectively. The higher frequency of excursions and the higher annual average concentration reported for station 14118 are probably due to ozone being scavenged by other pollutants at a slower rate in the rural setting where scavengers are less abundant than in cities.

Pollution roses for 1978 for ozone, which appear in Figure 7, Appendix 5, illustrate the percentage of the total number of excursions at each station that are associated with different wind directions. It is evident from the roses that the majority of excursions are associated with south and south-south-westerly winds. South and south-south-westerly winds are apt to be associated with the back of high pressure systems that have weather favourable for photochemical reactions (clear sunny skies and warmer temperatures) and that promote long-range transport of oxidants and its precursor chemicals from the United States.

Since the frequencies of excursions above the criterion are dependent on meteorological conditions, fluctuations from year to year are to be expected. Table 10, Appendix 5 is a summary of data for ozone since 1974.

FLUORIDES

In the Sarnia area fluorides are emitted into the atmosphere from fossil-fueled power plants where it is encountered as an impurity in coal, from a fertilizer plant where it occurs as a constituent of phosphate rock, and from petroleum refineries where it is used as a catalyst in alkylation.

Fluoridation rate is a measurement designed to indicate relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and subsequently analysed for fluoride content. This technique is inexpensive compared to other methods for measuring airborne fluorides. Some fluorides in particulate form are collected on the filters.

Criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. A criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ug F/100 cm^2/30 days) exists for the growing season of April 15 to October 15 and a less stringent criterion of 80 ug F/100 cm^2/30 days for the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is determined on a monthly basis, excursions above the criteria during these months are determined by comparing fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days).

The Ministry monitors for fluoridation rate at station 14004, located south of Courtright in the vicinity of the fertilizer complex of Canadian Industries Limited and power plants of Ontario Hydro and Detroit Edison, and at

station 14049 in downtown Sarnia. Canadian Industries Limited has maintained a detailed network of fluoridation candles prior to the commencement of its fertilizer operations in the 1960's.

During 1978 the criterion for the growing season was exceeded at station 14004 for the 5 consecutive months of May through September while the less stringent criterion for the non-growing season was exceeded during January. At station 14049 the criterion for the growing season was marginally exceeded for July, August and September while the less stringent criterion was exceeded for November. The annual average for fluoridation rate was higher at station 14004 than station 14049. Table 11, Appendix 6 presents data for fluoridation rate from 1972 to 1978.

Fluoridation rate serves to indicate if levels of fluorides exist that might cause vegetation damage. Annual phytotoxicology surveys have not revealed vegetation damage attributable to fluorides in Sarnia or outside of company property in the Courtright area.

APPENDIX 1

MONITORING NETWORK

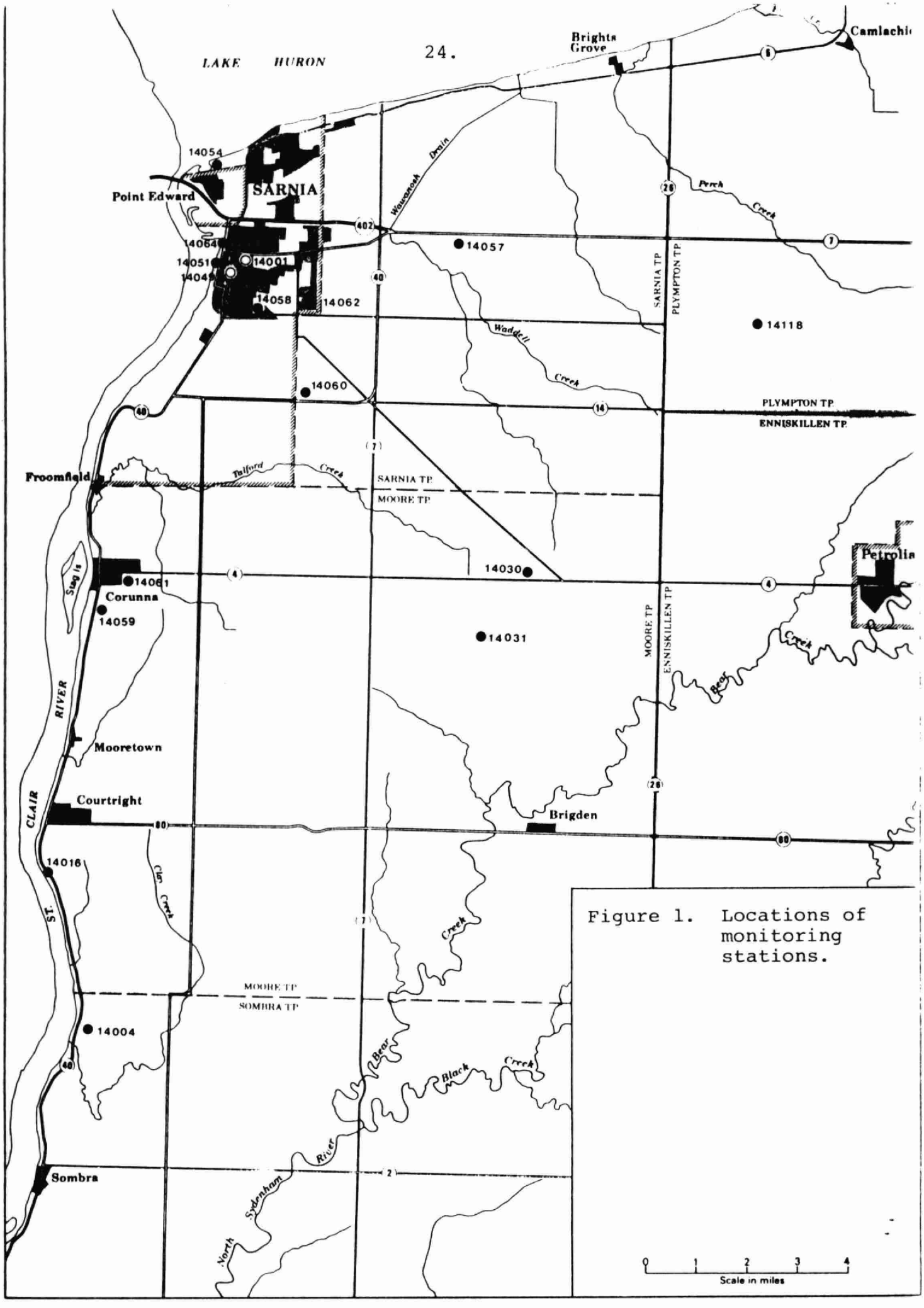


Figure 1. Locations of monitoring stations.

Table 1. Locations of monitoring stations and pollutants being monitored.

Station No.	Location	Parameters measured	Height of measurements	Purpose of station and comments
14001	Sarnia General Hospital	Suspended particulates	16 m.	Historical station which has been in operation since 1962. Does not reflect ground level concentrations but does indicate more direct effects of particulates from high stacks.
14004	5½ miles south of Courtright	Continuous SO_2, fluoridation rate.	4 m.	Monitors SO_2 from power generating stations and fluorides from fertilizer industry.
14016	1¼ miles south of Courtright	Suspended particulates continuous SO_2, sulphation rate WS, WD, Temp., WS, WD, Temp., WS, WD, Temp., telemetering equipment	1 m. 4 m. 4 m. 10 m. 30 m. 92 m.	Monitors suspended particulates and sulphur dioxides in relation to power generating plants. Provides meteorological data required for stability forecasts and air quality interpretations.
14049	Victoria Street downtown Sarnia	Continuous SO_2, CO, NO, NO_2, NO_x, H_2S and mercaptans, total hydrocarbons, 2-HR COH, 1-HR COH, suspended particulates dustfall, fluoridation rate, sulphation rate, telemetering equipment.	4 m.	Monitors main air pollutants in a heavily populated area where the pollutants from traffic, commercial establishments, and the heavily industrialized complex south of the monitoring station should be high relative to residential areas. Provides Air Pollution Index for Sarnia.
14051	Front and Lochiel Street, downtown Sarnia	Sulphation rate, suspended particulates, dustfall	3 m.	Monitors pollutants in commercial area which is also affected by heavily industrialized area to south. Since this is the location of a monitoring station operated by the Lambton Industrial Society, cross checking of monitoring techniques is possible.

Table 1. continued

Station No.	Location	Parameters measured	Height of measurements	Purpose of station and comments
14054	Sarnia Yacht Club	Sulphation rate, suspended particulates	5 m.	Monitors suspended particulates and relative amounts of sulphur oxides in the north Sarnia-Point Edward area.
14057	Briarwood Recreation Centre	Sulphation rate, suspended particulates	10 m.	Monitors suspended particulates and relative amounts of sulphur oxides in Sarnia Township, northeast of the main industrial area.
14058	Tecumseh Park Sarnia	Sulphation rate	4 m.	Monitors relative amount of sulphur oxides in south residential Sarnia, close to the industrial area.
14059	Riverbend, Corunna	Sulphation rate, suspended particulates	4 m.	Monitors suspended particulates and relative amounts of sulphur oxides in the residential area of Corunna which is surrounded by industry and generating stations.
14060	MacGregor Street & Hwy. 40, Sarnia	Sulphation rate	4 m.	Monitors relative amount of sulphur oxides in southeast Sarnia.
14061	Colborne and Fane St., Corunna	Sulphation rate	4 m.	Monitors relative amount of sulphur oxide in a residential area of Corunna.
14062	Eastland Plaza, 242A Indian Rd. S., Sarnia	Continuous SO_2, H_2S & mercaptans, sulphation rate, WS, WD	6 m. 10 m.	Monitors SO_2, H_2S and mercaptans in residential-commercial area of east Sarnia which is adjacent to refinery operations. Provides meteorological data useful in identifying sources of pollutants.

Table 1. continued

Station No.	Location	Parameters measured	Height of measurements	Purpose of station and comments
14064	Centennial Park Front Street, Sarnia	Continuous SO_2, CO NO, NO_2, NO_x, O_3, total hydrocarbons, 1-hr COH, suspended particulates, telemetering equipment	3 m.	Monitors main air pollutants in an area adjacent to downtown Sarnia and in line with many point sources of pollution located to the south of the downtown area.
14118	Petrolia Public Utilities Commission Pumping Station, 4 miles west of Wyoming	O_3	5 m.	Monitors ozone levels in a rural location.

Table 2. Desirable ambient air quality criteria established for Ontario

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Dustfall	7.0 gm/metre^2 in 30 days	Historical and in keeping with other control agencies
	4.6 gm/metre^2 (monthly average in 1 year)	
Fluoridation rate	40 ug F/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug F/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non growing season)
Hydrocarbons (total)	NONE	Effects of hydrocarbons vary widely depending on their chemical-physical nature.
Hydrogen sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours.
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours.
Nitric oxide	NONE	Reacts with oxygen to produce NO_2.
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against offensive odours.
	0.10 ppm averaged for 24 hours	Protection of human health and protection against offensive odours.

Table 2. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Nitrogen oxides	NONE	
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, adverse health effects.
Sulphation rate	0.7 mg of SO_3 per 100 cm^2 of lead peroxide per day based on 30 days of exposure	Serves to measure relative amounts of sulphur oxides over extended periods of time thus permitting comparisons to annual average SO_2 concentrations
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged for 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m^3 averaged for 24 hours	Based on impairment of visibility and health effects in conjunction with elevated levels of SO_2.
	A geometric mean of 60 ug/m^3 during 1 year.	Based on public awareness of visible pollution.
Cadmium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Protection of human health
Lead in suspended particulates	5 ug/m^3 averaged for 24 hours	Protection of human health
	A geometric mean of 2 ug/m^3 over a 30-day period	Protection of human health
Nickel in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Protection of vegetation
Vanadium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Protection of human health

APPENDIX 2

METEOROLOGICAL DATA

Table 3. Percent frequencies of wind directions at the 30-metre level of station 14016.

Year	N	NE	E	SE	S	SW	W	NW
1978	13.6	12.7	6.3	6.0	19.0	17.2	11.9	13.3
1977	11.3	9.8	5.3	7.2	18.5	21.2	14.1	12.6
1976	12.2	9.2	3.5	4.7	18.1	20.5	15.1	16.7
1975	9.4	11.6	6.7	7.6	19.3	20.5	12.9	12.1
1974	12.2	10.6	5.2	5.7	20.6	21.6	12.1	12.1
1973	11.6	11.0	8.1	7.2	15.8	20.6	12.9	12.8
1972	15.8	12.0	6.5	8.3	17.4	16.4	11.7	12.0

APPENDIX 3

PARTICULATES

Table 4. Summary of 1978 data for total suspended particulates

Station number	No. of samples collected	Annual geometric mean (ug/m^3)	No. of values greater than 24-hour criterion	Percentage of values greater than 24-hour criterion
14001	53	49	2	4
14016	57	43	2	4
14030	11	(is)	0	0
14031	12	(is)	0	0
14049	52	80	16	31
14051	59	68	10	17
14054	57	51	2	4
14057	55	45	1	2
14059	54	43	1	2
14064	24	(is)	0	0

(is) - insufficient sample to determine representative geometric mean.

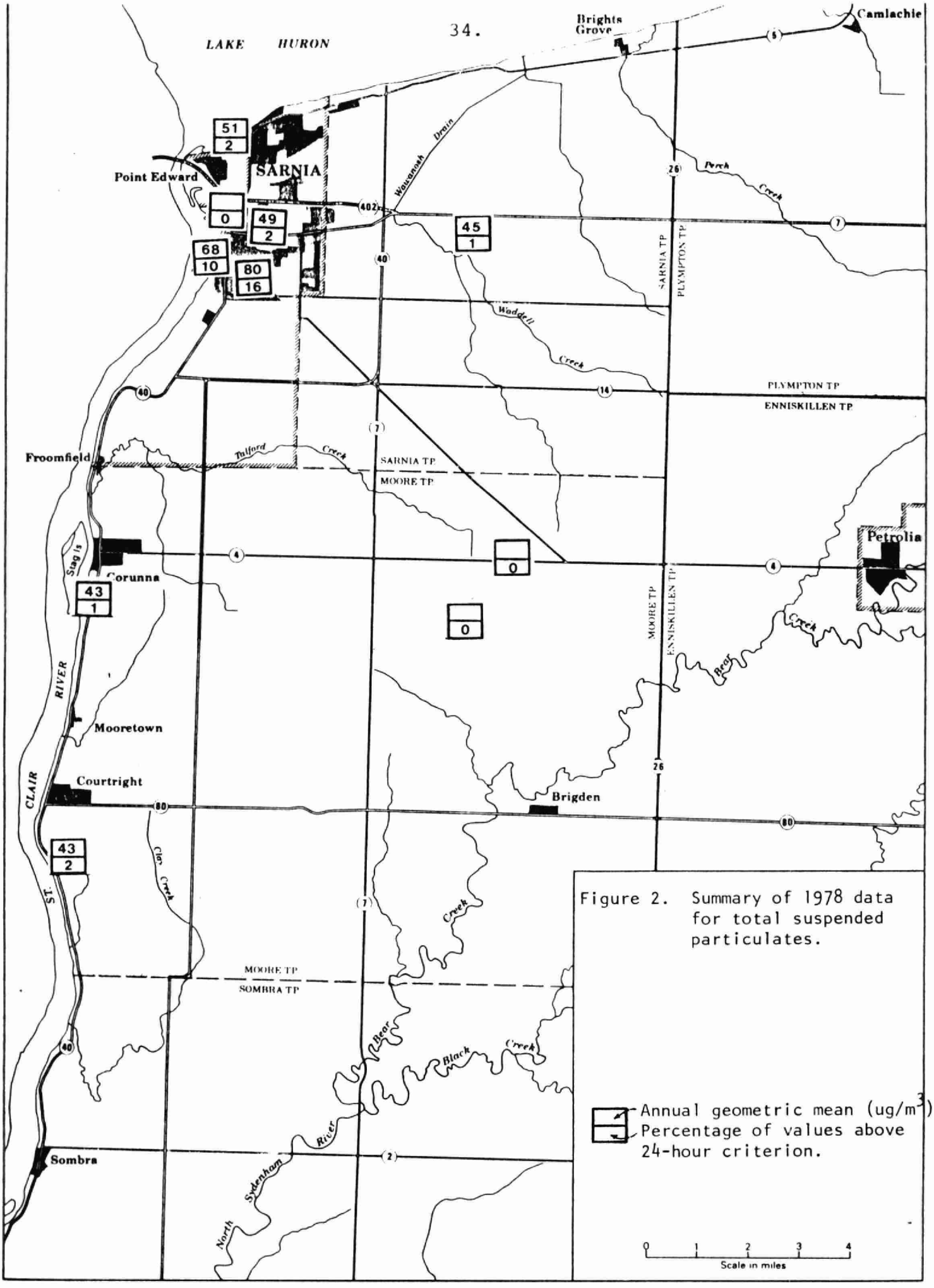
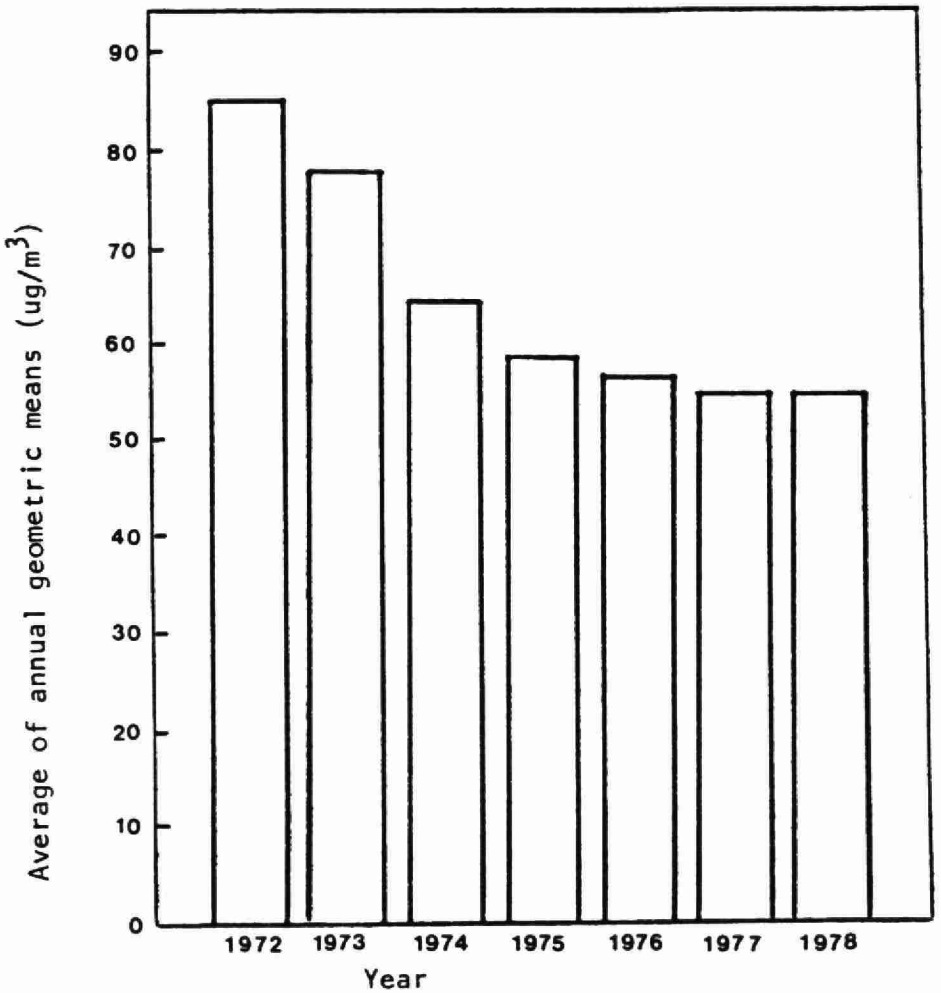
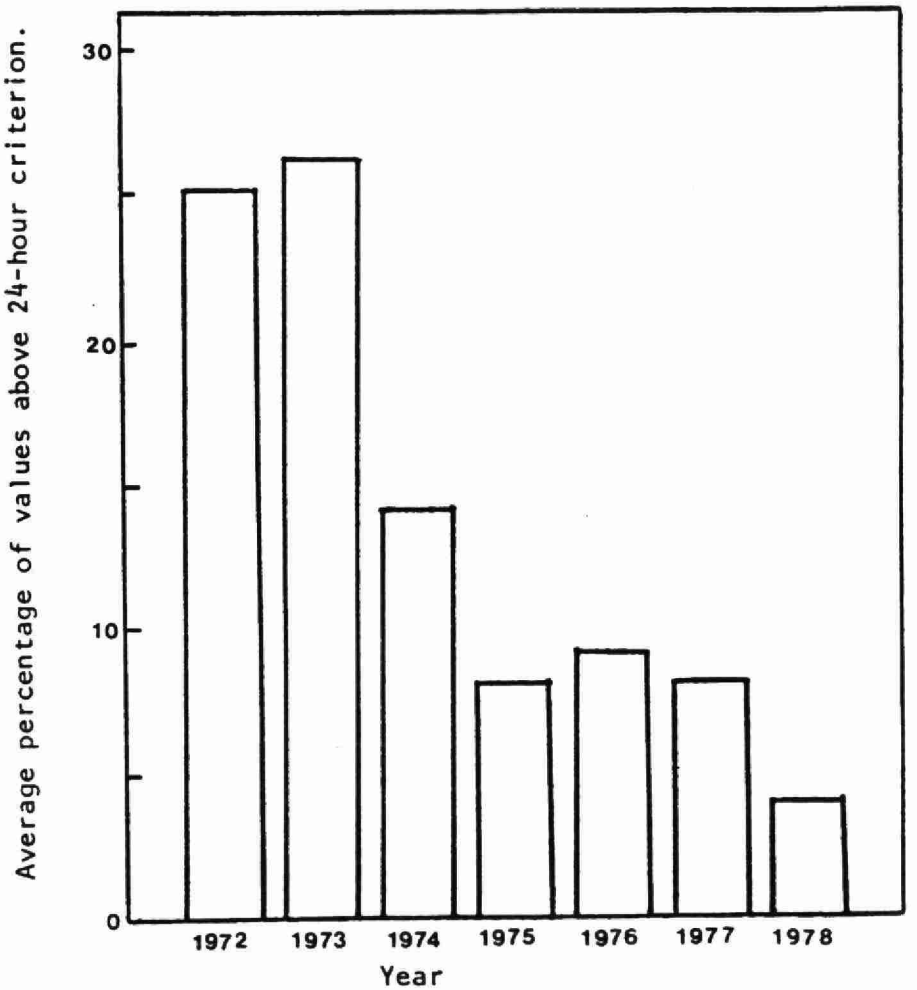


Figure 2. Summary of 1978 data for total suspended particulates.

Figure 3. Trend in levels of suspended particulates based on data averaged for seven monitoring stations from 1972 to 1978.





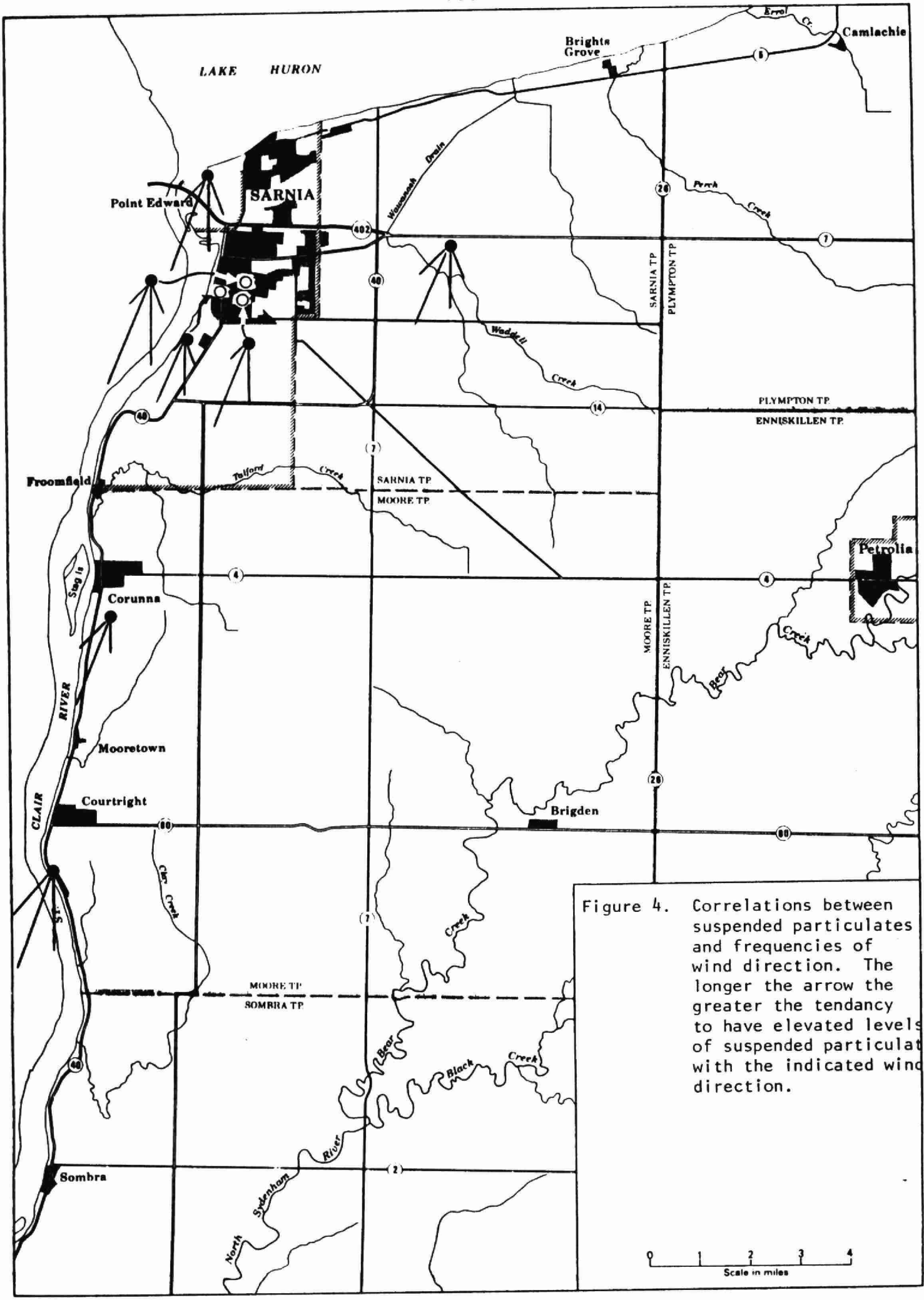


Figure 4. Correlations between suspended particulates and frequencies of wind direction. The longer the arrow the greater the tendancy to have elevated levels of suspended particulate with the indicated wind direction.

Table 5. Concentrations of various constituents of suspended particulates: 1976 to 1978.
(ug/m^3)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max[m]	Chromium # of samples	Chromium Avg.	Chromium Max[m]	Copper # of samples	Copper Avg.	Copper Max[m]	Iron # of samples	Iron Avg.	Iron Max[m]	Lead # of samples	Lead Avg.	Lead Max[m]
14001															
1976	10	0.001	0.004	10	0.017	0.066	10	0.31	0.73	10	1.0	2.4	10	0.3	0.6
1977	18	0.000	0.003	18	0.009	0.030	18	0.68	2.48	18	1.2	5.8	18	0.3	1.3
1978	24	0.001	0.005	24	0.010	0.023	24	0.22	0.54	24	1.1	4.0	24	0.2	0.7
14016															
1976	18	0.000	0.003	18	0.003	0.011	18	0.41	1.17	18	0.6	1.6	18	0.2	0.4
1977	21	0.000	0.002	21	0.008	0.025	21	0.31	0.58	21	0.6	1.8	21	0.2	0.6
1978	26	0.001	0.003	26	0.007	0.019	26	0.50	1.38	26	0.9	3.2	26	0.1	0.4
14030															
1978	11	0.002	0.004	11	0.007	0.019	11	0.37	0.98	11	1.2	2.2	11	0.3	0.9
14031															
1978	12	0.002	0.003	12	0.004	0.008	12	0.44	1.00	12	0.7	1.3	12	0.1	0.3
14051															
1976	17	0.001	0.003	18	0.032	0.157	17	0.08	0.15	17	1.0	3.4	17	0.3	0.8
1977	20	0.000	0.003	20	0.007	0.021	20	0.10	0.28	20	0.6	1.3	20	0.2	0.5
1978	21	0.001	0.005	21	0.006	0.016	21	0.09	0.40	21	1.0	3.1	21	0.3	0.9
14054															
1976	3	0.002	0.004	3	0.000	0.000	3	0.17	0.18	3	0.5	0.7	3	0.2	0.3
1977	15	0.001	0.003	15	0.003	0.010	15	0.46	2.16	15	0.7	1.9	15	0.2	0.5
1978	24	0.001	0.008	24	0.008	0.019	24	0.31	0.73	24	0.9	1.9	57	0.2	1.3

Table 5. Continued

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max^m	Nickel # of samples	Nickel Avg.	Nickel Max^m	Nitrates # of samples	Nitrates Avg.	Nitrates Max^m	Sulphates # of samples	Sulphates Avg.	Sulphates Max^m	Vanadium # of samples	Vanadium Avg.	Vanadium Max^m
14001															
1976	2	0.30	0.37	10	0.029	0.107	58	3.8	15.8	58	8.6	44.6	10	0.02	0.11
1977	18	0.04	0.23	18	0.014	0.064	47	4.7	24.5	48	12.9	43.9	18	0.01	0.07
1978	24	0.08	0.58	24	0.010	0.033	51	4.6	21.3	51	11.1	39.7	24	0.00	0.02
14016															
1976	8	0.01	0.04	18	0.013	0.031	96	4.0	20.0	105	8.7	33.4	18	0.00	0.02
1977	21	0.03	0.09	21	0.022	0.165	54	3.7	27.8	54	10.0	24.6	21	0.01	0.08
1978	26	0.02	0.06	26	0.016	0.194	53	4.6	24.6	53	11.2	35.3	26	0.00	0.10
14030															
1978				11	0.009	0.013									
14031															
1978				12	0.016	0.057									
14051															
1976	17	0.03	0.07	17	0.023	0.084	59	3.7	11.7	58	9.3	45.1	17	0.03	0.12
1977	20	0.03	0.06	20	0.009	0.022	56	3.9	22.4	56	10.9	32.1	20	0.00	0.02
1978	21	0.06	0.18	21	0.012	0.047	59	5.4	19.2	59	12.8	47.1	21	0.01	0.12
14054															
1976	3	0.02	0.04	3	0.023	0.063	54	3.7	13.2	61	8.9	34.8	3	0.02	0.03
1977	15	0.03	0.10	15	0.009	0.021	49	3.8	20.2	49	10.1	25.7	15	0.01	0.03
1978	24	0.04	0.12	24	0.005	0.024	49	4.8	20.4	49	11.5	37.0	24	0.00	0.04

Table 6. Values for dustfall (g/m^2/30 days) in downtown Sarnia

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Arithmetic Mean
Station 14049													
1972	*	7.4	7.7	7.0	2.1	*	2.5	3.2	2.1	4.2	*	3.2	4.4
1973	5.3	3.5	10.5	4.6	7.7	4.6	3.9	2.8	3.5	6.0	8.8	3.5	5.4
1974	3.5	4.6	9.8	5.6	5.6	6.0	4.2	2.5	3.2	3.5	4.2	3.9	4.7
1975	4.2	4.2	6.0	6.0	6.0	4.6	3.2	6.7	4.2	5.6	3.9	2.8	4.8
1976	2.8	6.0	8.1	6.7	5.6	4.9	4.9	3.2	3.5	4.6	4.3	4.2	4.9
1977	1.6	5.9	8.7	5.4	5.0	5.5	2.6	3.0	4.4	3.3	5.6	5.5	4.7
1978	1.1	2.0	9.1	7.1	3.0	5.5	4.1	2.9	4.5	2.0	3.7	6.4	4.3
Station 14051													
1972	*	*	*	7.4	*	*	2.1	6.7	4.9	3.9	*	3.2	4.7
1973	3.5	2.5	6.3	5.6	6.3	6.3	1.8	2.5	2.8	4.9	5.6	2.8	4.2
1974	3.2	4.9	7.0	7.0	5.6	7.0	4.9	2.8	4.2	4.6	3.2	4.2	4.9
1975	4.6	2.1	4.2	2.1	5.6	5.2	4.2	9.1	3.5	5.6	4.2	2.1	4.4
1976	3.2	4.9	6.7	5.3	4.9	4.6	3.5	3.2	2.8	3.2	2.8	2.8	4.0
1977	0.9	3.9	5.6	5.5	4.9	5.2	4.6	4.0	5.1	3.1	4.4	4.4	4.3
1978	1.5	0.9	19.7	12.7	6.3	5.4	4.8	4.3	7.2	4.7	4.6	3.7	6.3

Underlined values exceeded either the criterion of 7.0 gm/m^2/30 days or the annual criterion of an average of 4.6 gm/m^2/30 days.

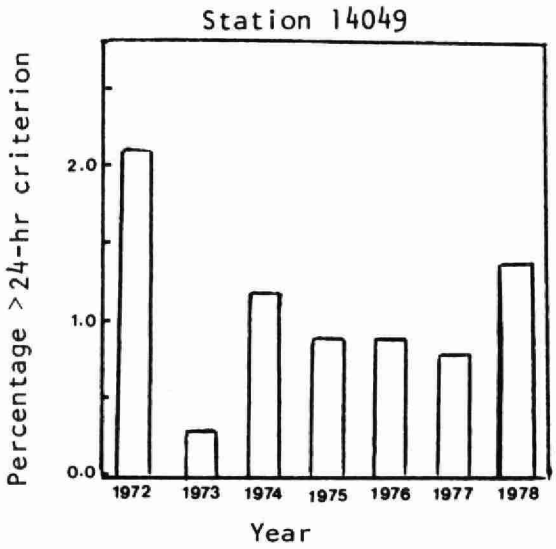
APPENDIX 4

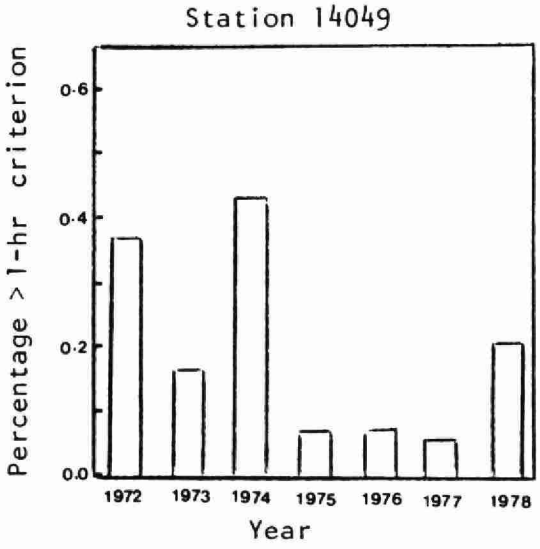
SULPHUR OXIDES

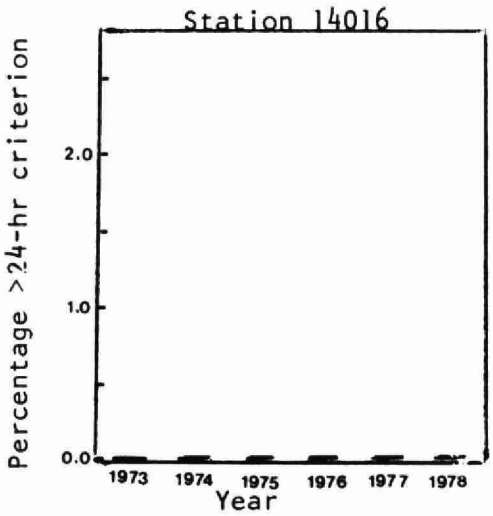
Table 7. Summary of 1978 data for sulphur dioxide

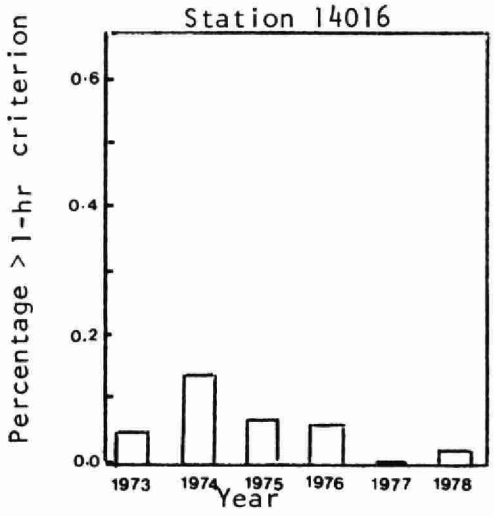
Station number	Annual average (ppm)	Percentage of values above: 1-hr criterion	24-hr criterion	Maximum 1-hour value (ppm)	Maximum 24-hour (daily) value (ppm)
14004	0.01	0.09	0	0.67	0.09
14016	0.02	0.02	0	0.32	0.07
14049	0.02	0.21	1.4	0.63	0.14
14062	0.01	0.00	0	0.22	0.05
14064	0.02	0.05	0	0.48	0.10

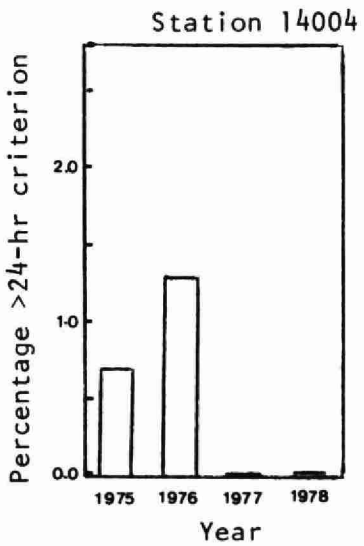
Figure 5. Trend in frequencies of excursions above 1-hour and 24-hour criteria for sulphur dioxide.

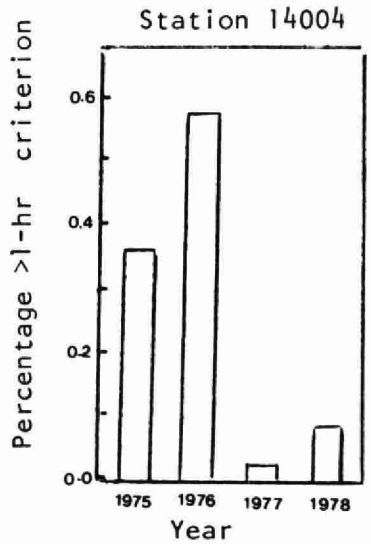












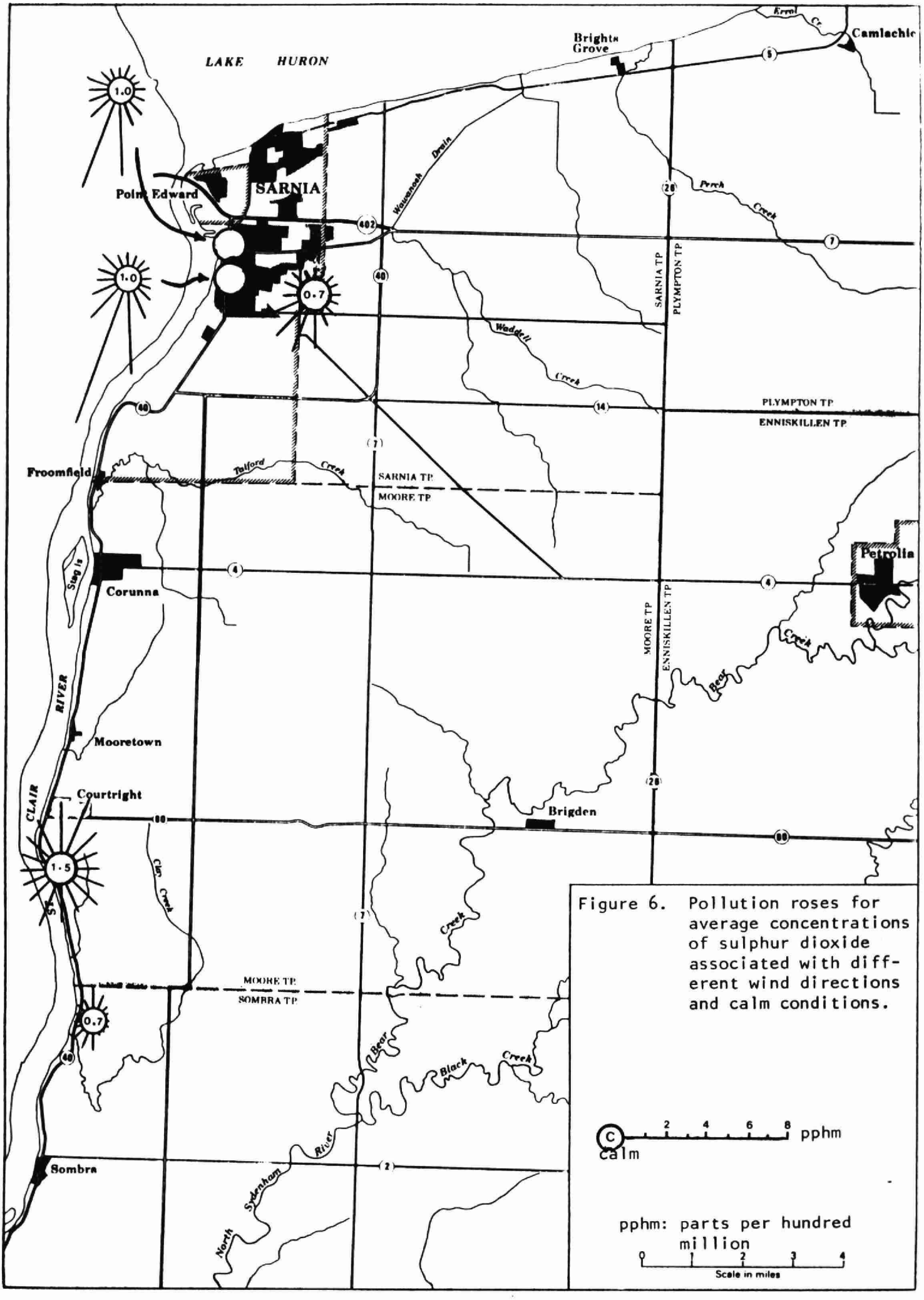


Figure 6. Pollution roses for average concentrations of sulphur dioxide associated with different wind directions and calm conditions.

Table 8. Sulphation rates during 1978.

Station number	Sulphation rates (mg SO_3/100 cm^2/day) January	February	March	April	May	June	July	August	September	October	November	December	Annual average
14016	0.74	0.61	0.51	0.61	0.68	0.67	0.48	0.37	0.39	0.43	0.44	0.54	0.54
14049	1.18	0.87	0.85	0.33	0.54	1.30	0.85	0.85	0.63	1.31	0.97	1.00	0.89
14051	1.31	1.09	0.79	0.58	0.55	1.31	0.82	0.97	0.67	1.48	1.18	1.15	0.99
14054	0.83	0.76	0.49	0.29	0.52	0.62	0.50	0.44	0.41	0.72	0.50	0.39	0.54
14057	0.53	0.46	0.33	0.23	0.23	0.48	0.28	0.32	0.25	0.40	0.44	0.47	0.37
14058	0.49	0.65	0.44	0.28	0.33	0.53	0.37	0.42	0.28	0.51	0.60	0.66	0.32
14059	0.58	0.83	0.51	0.69	0.94	0.85	0.76	0.57	0.42	0.58	0.55	0.43	0.64
14060	0.95	0.89	0.56	0.45	0.39	0.65	0.33		0.37	0.60	0.77	0.75	0.61
14061	0.66	0.74	0.67	0.82	0.94	0.86	0.76	0.64	0.55	0.61	0.52	0.57	0.70
14062	0.72	0.70	0.50	0.27	0.32	0.58	0.35	0.44	0.44	0.67	0.62	0.81	0.54

Note: Underlined values exceed monthly criterion.

APPENDIX 5

HYDROGEN SULPHIDE AND MERCAPTANS, CARBON MONOXIDE, OXIDES OF NITROGEN, TOTAL HYDROCARBONS AND OZONE

Table 9. Summary of data for hydrogen sulphide and mercaptans, carbon monoxide, oxides of nitrogen and total hydrocarbons.

Parameter	1978	1978	1977	1976	1975	1974
Hydrogen sulphide and mercaptans	station 14062	station 14049				
Annual average (ppm)	0.001	0.001	0.001	0.001	0.001	0.007
Percentage of values above: 1-hr criterion (1)	0.00	0.15	0.01	0.04	0.38	9.78
Carbon monoxide	station 14064	station 14049				
Annual average (ppm)	0	1	2	1	1	1
Percentage of values above: 1-hr criterion	0	0	0	0	0	0
8-hr criterion	0	0	0	0	0	0
Nitrogen dioxide						
Annual average (ppm)	0.02	0.03	0.03	0.03	0.02	
Percentage of values above: 1-hr criterion	0	0	0	0	0	
24-hr criterion	0	0	0	0	0	
Nitric oxide						
Annual average (ppm)	0.02	0.02	0.02	0.02		
Total oxides of nitrogen						
Annual average (ppm)	0.03	0.05	0.05	0.05	0.05	
Total hydrocarbons						
Annual average (ppm)	1.7	2.6	2.4	2.3	2.6	2.8

(1) Criterion for hydrogen sulphide

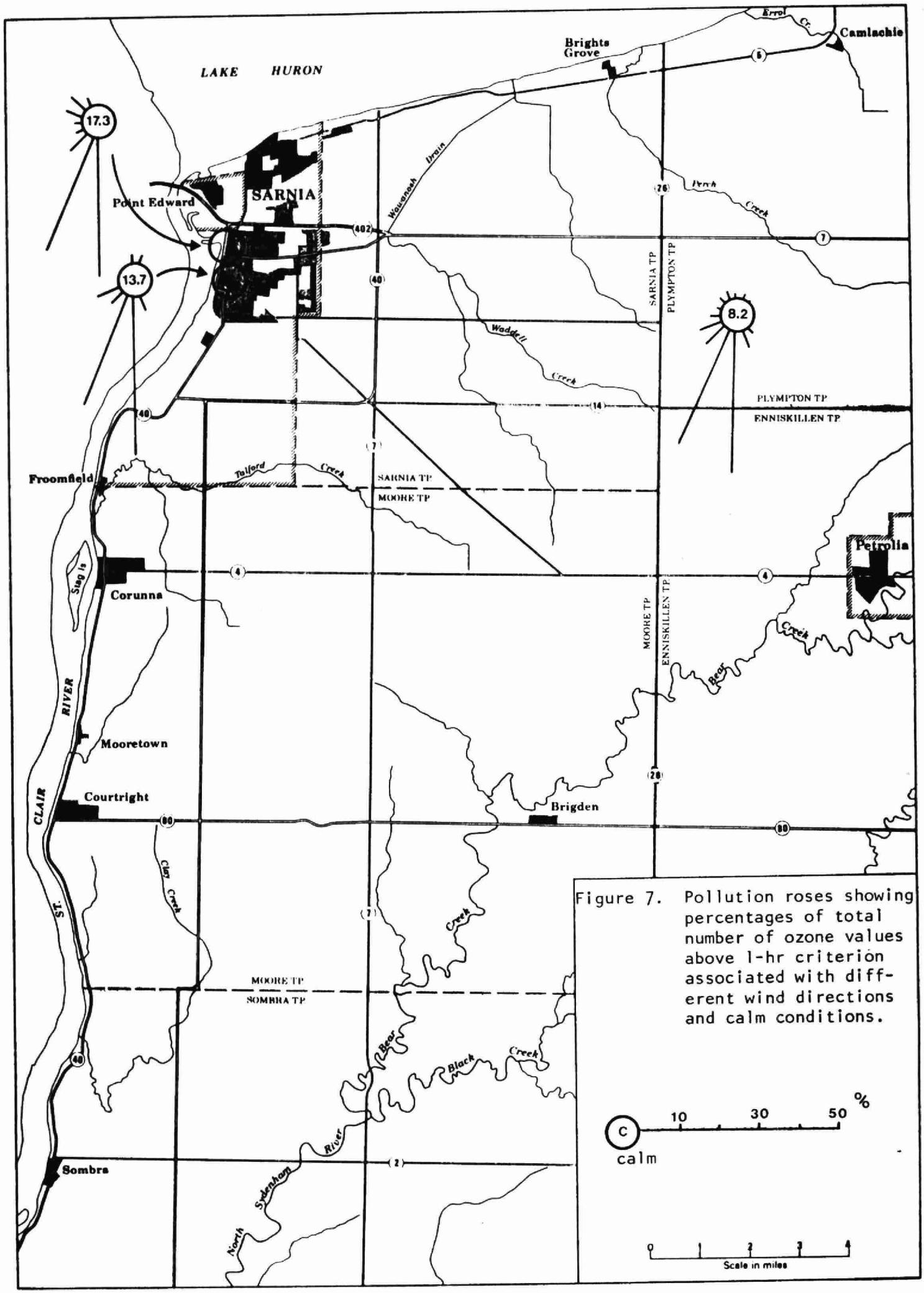


Figure 7. Pollution roses showing percentages of total number of ozone values above 1-hr criterion associated with different wind directions and calm conditions.

Table 10. Summary of data for ozone.

Station and parameter	Year 1978	1977	1976	1975	1974
Station 14049					
Annual average (ppm)	0.023	0.020	0.019	0.024	0.018
Number of values above 1-hr criterion	51	87	56	132	80
Percentage of values above 1-hr criterion	1.1	1.0	0.7	1.9	1.1
Station 14064					
Annual average (ppm)	0.018				
Number of values above 1-hr criterion	56				
Percentage of values above 1-hr criterion	1.4				
Station 14118					
Annual average (ppm)	0.029	0.027			
Number of values above 1-hr criterion	249	182			
Percentage of values above 1-hr criterion	3.5	2.6			

APPENDIX 6

FLUORIDES

Table 11. Fluoridation rates from 1972 to 1978 (ug F/100 cm^2/30 days)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average
Station 14049													
1972	85	60	22	32	28	56	29	80	20	23	17	45	41
1973	55	50	60	65	65	100	75	60	40	70	55	55	63
1974	67	56	44	66	18		48		50	44	66	80	54
1975	31	39	19	18		29	34	34	22	74	44	31	34
1976	37	53	36	11	18	24	6	42	32	27	29	31	29
1977	55	40	32	16	34	14	43	32	26	46	43	74	38
1978	72	47	38	22	29	39	43	49	45	30	97	55	47
Station 14004													
1976						46	38	74	48	39	21	40	44
1977	42	23	53	32	78	31		79	112	29	104	50	58
1978	83	51	53	57	100	65	94	74	74	57	53	59	68

NOTE: Underlined values exceeded criteria for desirable ambient air.

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